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HEALTH HAZARDS IN THE FIELD OF METALSMITHING

by Linda Weiss

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GOLDSMITHING HEALTH HAZARDS

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PREFACE AND ACKNOWLEDGEMENTS

As part of the requirements for my M.F.A. Degree at Cranbrook Academy of Art I had to prepare a thesis. Although my primary investigation and thesis were concerned with metal forming techniques, I became so involved with my investigation of health hazards that I subsequently decided to prepare an additional section to my thesis. Some portions of that thesis appear here, with additions and modifications that have come as a result of working with two industrial hygienists from Chrysler Corporation in Detroit. Both Bill Watt and Kent Foster have generously donated their time and expertise. I would like to take this opportunity to thank them on behalf of all the metalsmiths (goldsmiths, silversmiths, jewelers, enamellists, blacksmiths, etc.) who are concerned with a healthy working environment.

A special note to those business minded craftspeople attending the conference: Perhaps, right now, your major concern is the cost/benefit ratio. Of course many preventative measures cost money. But how do you figure the cost of losing your normal breathing capacity, or kidney function? In my opinion, most artists/craftspeople will find that careful management of the workspace and use of preventative measures will result in increased efficiency as well as better overall health.

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INTRODUCTION

In every aspect of my daily life I am, and have been for quite some time, concerned with promoting and maintaining my health. This concern naturally carries over into my working environment. It is my intent, here, to cover the topic of health hazards only as it pertains to the field of metalsmithing, and to suggest safer working alternatives.

Recently, at metalsmithing workshops and conventions, I have heard various presentations about health hazards. The speakers are usually doctors or health science engineers, and I have not found their information adequate, understandable or applicable to the way a metalsmith works. The information usually covers too broad a range, the whole "field of the arts", and is too technical medically and chemically to put to use. Through my research, I have found that the solutions to the health hazards that the metalsmith encounters are not that complex. What is required is that the metalsmith recognize potential hazards and undertake reasonable hygiene and protective measures.

I do not presume to be a doctor or a health science engineer. All of the information presented here has been weeded out of various manuals and texts concerning health hazards in the arts and in industry. This information has been gathered from the sources listed in the bibliography. For a more thorough, authoritative understanding of body functions, systems and occupational disease, I recommend that the metalsmith seek out these resources. I will try to cover most of the potentially hazardous situations and materials that the metalsmith, or jeweler, would encounter in 1) private studio practice, 2) classroom studio situation, and 3) limited production studio.

Very little research has been done on the medical problems of artists as a direct result of occupational health hazards. Most research has been done for industrial-type situations. In many cases, industrial workers have greater volume of exposure but, in industry, there are better facilities to deal with these problems. Thus, most metalsmiths are frequently working under much more hazardous conditions than commonly found in industry. Their lack of concern is frequently due to lack of knowledge about health hazards and safety precautions.

This points to one of the major dilemmas of the independent working metalsmith: locating pertinent, concise information about what materials are hazardous and alternatives for working with them safely. As part of their effort at solving this problem, in all art media, the New York Chapter of the National Art Workers Community made the following five resolutions:

"1. Art schools have a responsibility to set an example of how to work safely with art materials. Art schools should provide safe working conditions and should include, as an integral part of their curriculum, information on the health hazards of art materials and how to work with them safely.
2. Artists and craftspeople have a right to know the hazards of the materials with which they are working. Therefore, art suppliers should fully label their art materials both as to composition and hazards. In addition art suppliers should undertake research to develop the safest art materials possible.
3. Art supply stores should support full-disclosure labeling of art materials and should pressure art suppliers to conform to this standard. (Talk to your suppliers — they buy in bulk and when they repack they should also re-label stating precautions.)
4. Municipal, state and federal governments should pass adequate legislation for full disclosure labeling of art materials and any other legislation needed to protect the right to work in a safe environment.
5. Government agencies should sponsor research to investigate the occupational health problems of artists and craftspeople and should provide free medical treatment where necessary."

I feel that dissemination of information about health hazards throughout the art education system is very important. In this way, health and safety can become a work habit considered from the start, rather than added as an after-the-hazard afterthought.

The question of labeling is very important because if you don't know what's in a particular material, there's no way to know the potential hazards of working with it.

The main hazards most metalsmiths will encounter exist under the following circumstances: 1) inhalation, 2) ingestion, 3) skin contact. Many metalsmiths compound their personal hazards (as well as those who share their studio) by smoking cigarettes. Smoking makes ingestion of toxic substances easier, presents the danger of fire, and contributes to the total body burden of cumulative poisons. There has also been increasing evidence that inhalation of vapors from solvents may increase the risk of cancer much greater for cigarette smokers. Some other individuals who will probably be more susceptible to environmental and occupational contaminants are children, people with allergies, older people, and people with previously damaged organs (especially liver, heart and lungs).

Most of the substances that a metalsmith will encounter do not pose immediate major danger. However, most of these substances are cumulative toxins and have a long-term effect. Doctors refer to this as chronic effect. The problem with this is that the symptoms do not occur at the time of exposure. They build up gradually until the body's tolerance of toxin is reached. This tolerance level will vary from person to person depending on 1) overall health, 2) age, 3) environment. Most cumulative damage climaxes in around 20 years – that, for someone in their early twenties, could mean cancer at the age of forty.

Actually, I really don't intend this article to cause anxiety so much as caution. I hope this information will serve other metalsmiths who are concerned about health and maintaining a safe working environment. The solutions that I offer for minimizing health hazards should be understood to be general guidelines and, of course, will probably have to be modified to fit every individual's personal workshop conditions and working habits.

HOW HARMFUL SUBSTANCES ENTER AND AFFECT THE BODY

Most substances that are potentially harmful to the metalsmith must get on, or in, the body to do any damage. A toxic material is harmless when it sits in the appropriate container. Toxicity is the potential of a material to affect living cells adversely. Conditions that will influence the toxicity of a given substance are (a) quantity of dose, (b) rate of absorption and (c) route of entry. The degree of toxicity is greatest by the route that the harmful substance takes to reach the bloodstream most rapidly. For metalsmiths, inhalation is the primary avenue for most toxins reaching the bloodstream. Skin contact is the next most important means, followed by ingestion. Almost all materials the metalsmith encounters have the potential to cause bodily harm. However, a toxic substance is not a health hazard until it is mis-used. The key is to know about these substances and to maintain a safe studio and healthy work habits.

The body is capable of coping with small doses of toxic materials. Almost every activity in daily life, and in the environment, brings us in contact with toxic substances. It is my opinion, from the research I have done, that the level of toxins in a private studio, academic studio and commercial studio are of high enough concentration to be given special consideration.

LUNGS—The lungs, under normal circumstances, can clear themselves. However, one can gain a deceptive sense of self confidence by thinking in terms of only a single pollutant.

Such thoughts as "I'm only exposed to soldering fumes for twenty or thirty minutes each day" tells very little about the total assault on the lungs. We must also contend with solvent vapors, acid mists, kiln burnout, enamel fumes and abrasive particulates. If one recognizes the concept of multiple insults of different materials on the same organs, this false level of confidence is not justified. (Especially since so many of the toxins we come in contact with are cumulative.)

When irritants injure the lungs, it is usually something equivalent to a burn. As in response to any burn, the injured tissue will pour out fluid from the bloodstream. Fluid accumulation in the lungs interferes with oxygen exchange. This can lead to a type of suffocation called pulmonary edema. (Edema means swelling caused by fluid). If this is not fatal, there is usually permanent lung damage called pulmonary fibrosis (scarring).

Whether or not a substance gets beyond the lungs to affect the rest of the body depends on whether it is soluble in the blood.

BLOOD—Substances that affect the blood can have very serious effects on the brain, kidneys and heart. Red blood cells are responsible for transporting oxygen, in the hemoglobin, to all body tissues. White blood cells make antibodies to maintain the body's immunity system and help fight infections. Some harmful fumes attack the bone marrow – this affects its ability to produce new blood cells.

LIVER—The liver functions to detoxify substances that are produced by body processes as well as harmful substances that enter the body from the environment. When the burden of toxins is too great, the liver will be damaged and will not be able to detoxify any poisons, the body's or otherwise. Hepatitis, commonly known as a viral disease, can also be caused by chemical substances. In severe cases, this can lead to scarring of the liver (cirrhosis). Symptoms of liver disease are often vague. A yellow tint to the skin will indicate liver damage (jaundice).

KIDNEY—The kidneys function as filters which help to maintain balance or a constancy of the internal environment. They individually monitor and regulate most of the major constituents (proteins, sugars, salts, water and waste products) of the blood, as well as several minor constituents. Since approximately 2000 liters of blood flow through the kidneys each day, a nephrotoxin in the blood which reaches the kidneys may cause severe damage. The kidney function may be impaired or the damage may result in complete failure.

Coke-oven workers have a high incidence of kidney cancer. So it is advised that blacksmiths who use coke for fuel have good exhause ventilation if their forge is maintained indoors.

THE NERVOUS SYSTEM—When the central nervous system is damaged, the damage is permanent. The central nervous system consists of the brain and the spinal cord. Some toxins in metals can cause CNS damage, others can damage the peripheral nerves, which are considered to be a separate system. The brain cannot survive very long without oxygen, and many of the substances that the metalsmith encounters have the potential to interfere with the body's oxygen supply. Some warning symptoms are dizziness, drowsiness, and feeling intoxicated.

EARS—Excessive noise can have both temporary and permanent effects on the ears. Many metalsmithing processes produce high levels of noise. This ranges from hammering to machines, grinders, power mills, lathes, etc. Almost all occupational ear damage could be prevented by wearing ear plugs and/or ear muffs. People who wear eye glasses should be aware that the temple part of the glass frame can reduce the effectiveness of ear muffs by 30% because they prevent proper sealing around the ear. Such people are advised ear muffs with ear plugs.

SKIN—Skin ailments are one of the most frequent occupational hazards caused by chemical substances. There is no mystery about a skin ailment—it's always visible. It has been estimated that more than 90% of occupational dermatitis is preventable by simple principles of industrial hygiene. Proper gloves and protective clothing should be worn. Even if a substance is not causing a skin reaction, these precautions should be used because many harmful substances are absorbed through the skin without necessarily irritating it.

Substances that damage the skin directly are called primary irritants. These substances penetrate the outer layers of the skin and injure the underlying layers. In the case of primary irritants, all people exposed to the same concentrations of these substances will have identical skin irritation.

The skin irritation caused by direct contact with chemicals can look like any other form of dermatitis: pimples, sores, flakes, etc. But it always appears where direct contact with the substance occurs, and usually goes away when contact with the irritant has ended. Such dermatitis does not usually spread to other parts of the body.

Substances that aren't normally irritating may cause dermatitis if the skin *develops* an allergy to them. Once the body's immune system has "learned" to react against a substance this way, it will "remember" the reaction for years, even with infrequent contact with the irritating substance. In some cases, the reaction is no longer present. In other cases, the reaction will only re-occur when the body comes in contact with the original irritating substance, or a similar one at a later time.

Contact dermatitis or sensitization takes time to *develop.* It never occurs on the initial exposure to a new substance. Cases have been known where people would suddenly develop an allergic reaction to a substance they had been using for many years. However, when the skin develops a sensitivity to one substance, that does not necessarily increase the changes of becoming sensitive to another unrelated substance.

The following section has a list and a dictionary of harmful substances. In cases where alternatives are not offered, the reader may find safety measures covered in another section of this paper. If there is no safer alternative found elsewhere, it is because, in my research, there was none suggested. The reader may interpret this as he/she likes.

POTENTIALLY HARMFUL SUBSTANCES ENCOUNTERED BY THE METALSMITH

ABRASIVES—Silica dusts; chromium emery; rubber adhesives; resin bonding agents

ACIDS—Aqua-Regia; cyanides; ferric chloride; hydrochloric; hydrofluoric; nitric; sulfuric; sparex

FUELS—Acetylene; arsine; carbon black; carbon monoxide; coke; oxy-acetylene; phosphine; propane

ENAMELLING—Arsenic; carbon monoxide; cerium; flourides; lead

METALS—Aluminum; antimony; cadmium; chromium compounds; copper compounds; lead; magnesium compounds; manganese compounds; mercury; nickel compounds; pewter; platinum; silver compounds; stainless steel; tellurium; tin compounds; titanium; zinc compounds

PLASTICS—Epoxy resins; phenolic resins; polyester resins

SOLVENTS—Acetone; Attack (brand name); benzene; chlorinated hydrocarbons; ketones; laquer thinner; methanol (methyl alcohol); naptha; toluene/toluol; turpentine; xylene

MISCELLANEOUS—Ammonia; asbestos; flourides; fluxes; hydrogen sulfide; investment; liver or sulfur; mica; pitch; solder; styrofoam; sulfur dioxide; talc; wax

DICTIONARY OF SUBSTANCES

ABRASIVES—See individual listings for silicas and dusts.

ACETONE—a solvent. Very flammable. Flash point—4 degrees F. Acute toxic effects: headache, drowsiness, irritation of eyes, nose, throat; vomiting. It is one of the least toxic solvents, is quickly eliminated by the body, has little residual effect. Because it is highly flammable, it should be used with great care. Acetone will dissolve surgeons rubber gloves.

ACETYLENE—fuel. Commonly used in cylinder form. In low concentrations, acetylene is a mild narcotic or intoxicant. In large concentrations, it can cut off oxygen supply. Commercial acetylene is contaminated with PHOSPHINE, HYDROGEN SULFIDE, ARSINE, CARBON DISULFIDE AND CARBON MONOXIDE — all are extremely toxic. See individual listings for these substances. Acetone is always present in the cylinder — DO NOT LAY THE CYLINDER DOWN!

ACIDS—See individual listings. Most acids are caustic and irritating to the skin, mucous membranes of the nose and eyes, and the lungs. ALWAYS ADD ACID TO WATER, never the reverse! Heat is usually generated and an explosion could result. When working with acids, one should wear protective clothing, work under an exhaust fume hood and have an eye wash station close by. Respirators for acids are different than respirators for particulates. Acids should be returned to the distributor for proper disposal.

AMMONIA—Usually used for cleaning buffing compounds from a piece. It is caustic to the lungs, may lead to pulmonary edema (when lungs fill with fluid), or pneumonia and lung scarring. It is an eye irritant both in solution and in gas form (fumes), usually damaging the cornea. Effects of long-term exposure to ammonia in low doses have not be studied, but this would probably perpetuate chronic bronchitis and emphysema. Ammonia would best be used in extremely diluted solutions of soap and water.

ANTIMONY—Used in pewter. It has not been established if antimony is harmful. The oxide is probably not toxic, but it can cause dermatitis.

AQUA REGIA—This acid, called "royal water", is very powerful. It will dissolve or etch gold as well as silver. It is made by adding one part nitric acid very slowly to three parts hydrochloric acid. Its bottle should never be tightly stoppered. Its fumes are highly corrosive, and it should be stored and used in an area that is well ventilated.

ARSINE—a contaminant in commercial acetylene; an eye, nose, throat and lung irritant. Can cause kidney damage; destroys red blood cells, can cause brain poisoning.

ARSENIC—released in fumes from some enamels when fused. Causes skin cancer, thickening of the keratin, or outer layer, of the skin, and perforation of the nasal septum. Causes nerve function disorder. Kilns should be well ventilated.

ASBESTOS—is mostly harmful in dust form. It is frequently used for its fire resistant properties. It is a carcinogen — its effects take 20-30 years to develop in humans. It causes ASBESTEOSIS, a lung scarring and MESOTHELIOMA, cancer of the lining of the chest. Asbestos is the only cause known of these two diseases. It is an insoluble substance, one that will not dissolve in the blood and tends to remain in the lungs for long periods of time; the lungs cannot remove it or destroy it.

"Asbestos is a fibrous material. Like cotton, its fibers can be made into thread and cloth. Unlike cotton, its fibers are as strong as piano strings."[1] These very strong fibers are very tiny also and can float like water vapor in the air, rarely settling. They are virtually indestructible in the body, and in the environment. Asbestos also has been found to have the ability, and tendency, to absorb other harmful chemicals onto its surface. It can also cause cancer of the intestinal tract, stomach and rectum. Alternatives that can be substituted for asbestos are: pea pumice, as is found in annealing pans; charcoal blocks; fire bricks; magnesium blocks; Wesgo refractory block; heavy leather gloves and aprons. Also, if a casting crucible is properly prepared by melting borax in it, and students are carefully supervised, asbestos lining of a crucible will not be necessary. Substitutes for asbestos fabrics, like gloves and fireblankets, are KEVLAR and REFRASIL. "It has been found that smokers have 10 times a greater chance of getting lung cancer than non-smokers. Non-smokers who work with asbestos have 10 times the chance of getting lung cancer as people who do not contact asbestos. But people who both smoke and work with asbestos have 100 times the chance of getting lung cancer."[2]

ATTACK—a brand name of a very efficient epoxy solvent. It contains CHLORINATED HYDROCARBONS. Avoid skin contact and use with good ventilation.

BENZENE—a solvent for plastics. Very flammable. Flash point 12 degrees F. Intoxication, coma, respiratory failure; can be fatal. Causes severe damage to bone marrow leading to fatal anemia or leukemia. Use an alternative, less toxic solvent. DO NOT USE! Solvents, like acids, should be returned to the chemical distributor for proper disposal. Do not pour down plumbing.

CADMIUM—is found in silver soldering and silver brazing compounds. Cadmium fumes can occur during casting and welding also. Know if your alloy contains cadmium. Change alloy or provide good ventilation. Cadmium affects the brain, nervous system, lungs, kidneys, bone, prostrate and digestive tract. It can cause acute bronchitis, pneumonia, digestive disorders, dermatitis, allergic hypersensitization, chronic brain damage, lung damage, prostate cancer and kidney stones.

Because of its extreme toxicity, products containing cadmium are required by law to be labeled. Ask your supplier to label solders.

CARBON BLACK—refers to the specific product of incomplete burning of fuel (natural gas, acetylene). Exposure to large quantities can cause lung scarring and promote skin cancer.

CARBON MONOXIDE—incomplete combustion when firing kilns, doing welding or copper enamel. Carbon monoxide poisoning affects the blood hemoglobin preventing the transport of oxygen to the heart, brain and lungs. It can be detected in extremely advanced stages because the victim's face and fingernails turn cherry red. Good ventilation will prevent carbon monoxide poisoning in the average studio. It should be remembered that carbon monoxide is colorless and odorless.

CHLORINATED HYDROCARBONS—solvent for plastic and waxes; very toxic. Dissolves fatty layer of the skin, causes dermatitis, liver and kidney damage. In general, **try** to replace chlorinated hydrocarbons with less toxic substances. When this is not possible, use good exhaust ventilation and wear protective gloves. Neoprene rubber is best — do not use butyl rubber or natural rubber.

CHROMIUM COMPOUNDS—fumes from chromium compounds are produced in welding. There is a much greater danger from a gas or fume form than from solid form of most toxins. It affects the skin, dermatitis, lungs; inflammation, asthma, and cancer; lining of the nose and nasal system. Use good ventilation.

COPPER COMPOUNDS—copper has been found to be highly toxic to animals in test situations, but there has been little testing in industrial circumstances involving people. Fumes of copper oxide are poisonous, irritating the lungs and intestines. It causes metal fume fever; recovery is usually complete in 1 or 2 days. Eyes and skin are sensitive to copper. There is no conclusive evidence about long-term exposure. Good ventilation is recommended for processes that involve heat, leading to the formation of copper oxides. If the metalsmith find some type of dermatitis developing, he/she may want to wear gloves when handling copper-containing alloys.

CYANIDES—sodium cyanide, ferrocyanide, cuprous cyanide and free cyanide are all used in electroplating bath formulas. It is known that the mist of cyanides are harmful, and one should use good ventilation and/or the appropriate respirator. It is also suspected that cyanide mists cause harm when absorbed through the skin, so protective clothing is advised.

EPOXY RESINS—cause contact dermatitis. It is recommended that gloves be used. During the mixing and curing processes, use good ventilation and avoid inhalation of dusts and fumes, and avoid skin contact with uncured epoxy resin and hardeners.

FERRIC CHLORIDE—used as a metal etching acid when a sharper etch is desired than can be achieved with nitric acid. Can irritate the skin and the respiratory tract. Use protective clothing and good ventilation.

FLOURIDES—found frequently in fluxes. They produce hydrogen flouride vapors which dissolve in the lungs where they produce hydroflouric acid and burn the lungs. Have your supplier label flux contents. Use good ventilation. Avoid breathing fumes.

FLUX—see FLOURIDES.

GOLD—some people are allergic to gold. They should prevent skin contact. This is probably a reaction to the alloys in karat gold.

HYDROCHLORIC ACID—(hydrogen chloride) used in metal patinas and etching. An irritant to mucous membranes. In mist and gas forms, this acid can damage lungs, cause tooth erosion and damage cartilage in the nose. Use good ventilation and prevent skin contact.

HYDROGEN FLOURIDE—(hydroflouric acid) used in enameling to etch glass. Skin contact should be avoided. If it does occur, flush area with water and see a doctor. Fumes affect the lungs, leading to bronchitis, pneumonia, etc. Do not breathe acid mists.

[1] Stellman—*Work is Dangerous to Your Health.*

[2] McCann—*Health Hazards Manual for Artists.*

HYDROGEN SULFIDE—a byproduct of using liver of sulfur in combination with water and heat. It is characterized by an odor like "rotten eggs". See LIVER OF SULFUR. 10 ppm (parts per million) is the threshold limit value. It is more toxic than cyanide. In high concentrations it can paralyze the olfactory nerve.

INVESTMENT—avoid inhalation of dust; wear a particulate mask. Use recommended ventilation when mixing large quantities.

LEAD—lead is a cumulative poison. Its compounds and its oxides should be treated carefully. It can be found in some bronze alloys and in some enamels (and we are all exposed to it from automobile exhaust fumes). It is harmful in dusts and in fumes, causing damage to the brain, central nervous system, red blood cells, bone marrow, liver and kidneys. Use protective measures and good ventilation. Lead fumes are very toxic. The body will absorb five times as much lead into the blood via the lungs than from the digestive tract. The body will retain lead for long periods of time, leading to cumulative poisoning; it is stored in the bone marrow.

KETONES—acetone, methyl ethyl ketone, methyl propyl ketone, methyl butyl ketone, ethyl acetate, amyl acetate. Lacquer thinner is a mixture of several of these solvents. Flash points vary from -4 degrees F to +89 degrees F. Ketones are skin, eye and respiratory tract irritants. They cause defatting of the skin and peripheral nerve damage. Use gloves and good ventilation and/or appropriate respirator.

LACQUER THINNER—see KETONES

LIVER OF SULFUR—is potassium sulfide and it is used to oxidize metal (gold, silver, copper). When it is heated to decomposition, it will emit highly toxic fumes of oxides of sulfur. These can react with moisture to produce another toxin — hydrogen sulfide, which is caustic to the eyes, the lungs and corrosive to mucous membranes. In high concentrations (around 700 ppm) it can cause suffocation and brain damage. Wear a respirator and work in a well ventilated area. (see HYDROGEN SULFIDE)

MAGNESIUM COMPOUNDS—in the forms of m. silicate, m. chromate, m. oxide. Encountered in welding fumes. It is known to affect the lungs, cause digestive disorders, metal fume fever, and is believed to affect the central nervous system. Use good ventilation when welding.

MANGANESE COMPOUNDS—m. carbonate, m. dioxide-black, m. dioxide-green, m. sulfates. Manganese is encountered in fumes from welding (it is frequently used to coat welding rods) and enameling. It affects the liver, lungs and central nervous system. Symptoms are headache and weight loss. Diseases that can result are pneumonia and manganism which is a permanently crippling disease of the central nervous system similar to Parkinson's Disease. Provide good ventilation in welding areas.

MERCURY—mercury is a cumulative poison. It may be encountered in gold and silver refining, and in welding. It affects the brain, kidneys and nervous system. Mercury can be used to gild silver; however, electroplating is more commonly used.

METHANOL—(methyl alcohol) is often found in a small percent in denatured alcohol which is frequently used as a solvent for pitch, and a fuel for alcohol lamps that may be used when working up wax models for castings. In high concentrations, it attacks the respiratory system, gastro-intestinal system, central nervous system, the liver and the optic nerve. Use proper ventilation.

MICA—used for plique-a-jour enamel work. Can also be found as a filler in some plastics. It is a silicate and should be handled carefully. It is advisable to wear a particulate mask.

NICKEL COMPOUNDS—nickel is found in the alloy called German Silver. n-oxide-green, n. oxide-black, n. carbonyl — are byproducts of welding nickel alloys, like stainless steel. Nickel carbonyl is the most toxic of the nickel compounds. Its gas can be absorbed by inhalation and through the skin. Body systems affected are the lungs (asthma and cancer) and the central nervous system. Skin contact with nickel salts may cause nickel itch, an allergic dermatitis. Once this sensitivity develops, the person will react to even extremely small amounts of nickel. Wear protective clothing and work in a well ventilated area.

NITRIC ACID—usually used for etching metal. Very irritating to lungs. Symptoms of over-exposure are chills, fever, chronic cough. When etching copper, nitrogen oxide fumes are produced; these dissolve in the lungs and can cause pulmonary edema and chemical pneumonia. Also, very irritating to the eyes. Exposure to low concentrations over extended periods of time are cumulative in terms of burning and scarring of the lungs. Wear protective clothing and work in a ventilated area or wear a respirator designed to cope with acid mists. Return all acids to the chemical distributor for proper disposal. Do not pour down plumbing or dump outside.

OXY-ACETYLENE—(see ACETYLENE) Use eye protection with tinted glass that is impact and heat resistant and will prevent penetration of radiation.

OZONE—occurs during welding. It destroys enzymes in body tissues. It has a distinctive odor (you can smell it during a lightning/thunder storm). Prolongs inhalation above 0.05 ppm can cause burning of the cells in a manner similar to X-rays. It can be detected by continuous monitoring devices.

PEWTER—pewter used to be made from tin and lead. Modern pewter is an alloy of tin and antimony and copper. Extreme care must be used if one is working with the older alloy because of its lead content.

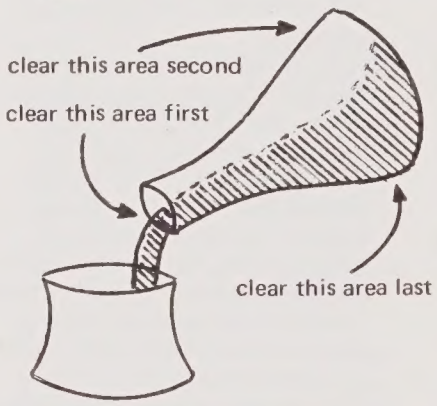
PHOSPHINE—a contaminant in commercial acetylene. Has been known to cause kidney damage and is an irritant to eyes, nose, throat and lungs.

PITCH—when pitch is made from a coal tar derivative like asphalt, it can be a skin irritant and photo sensitizer, leading to skin cancer after repeated, intermittent exposure over many years. When using pitch for chasing, repousse and engraving, it is advised that gloves be worn when handling the pitch itself. Once the work is secured in the pitch, the gloves can be removed to use your chasing, repousse, and engraving tools efficiently. If the fingers need to be braced on an area that is exposed to pitch, the pitch can be covered with Saran wrap with a very thin coating of petroleum jelly, if desired, as a separating agent between the Saran wrap and pitch.

True "Brown Swedish Pitch" is a pure vegetable pitch and can be differentiated from pitch adulterated with rosin and bitumin (coal tar products) by color; it is brown and has an agreeable odor. Pitch that is not the pure vegetable type is black and gives off offensive vapors. To test for color, Swedish pitch, when melted and pulled out very thin, shows clear translucent brown when held to a light. Precautions should be used when working with either type of pitch but the Brown Swedish Pitch is far less hazardous.

Care should be taken not to overheat pitch. Boiling destroys the tenacity and it becomes a fire hazard. Pitch, when heated, tends to form a skin on its top surface and to trap explosive gases underneath. To avoid this, heat the pitch slowly and evenly, occasionally stirring to break the skin and release these gases. It is wise to use good ventilation when melting either type of pitch.

Extra care is needed when a large bodied vessel with a narrow opening has to have pitch removed from it. Pitch expands with great force when heated. If the mouth of the vessel becomes clogged with hard pitch, while the pitch behind it approaches the melting point, an explosion can result. This problem can be solved by laying the vessel so the opening is a little lower than the body and warming the opening first. When the opening has been cleared of pitch, direct the soft flame to the "top" of the vessel.



PLATINUM—metallic platinum is nontoxic, but some platinum compounds can cause contact dermatitis and respiratory allergic reactions which have been known to lead to asthma and emphysema. Fumes from platinum that are encountered in soldering, casting, or refinishing, should be avoided. They are lung and skin irritants.

POLYESTER RESINS—one of the many plastics that metalsmiths use. They are skin irritants, and protective clothing should be worn. When casting these substances, harmful vapors are given off from catalysts, thickeners, binders and other additives. They should be used with good exhaust ventilation or respirators. Read the labels regarding proper storage. Some organic catalysts are heat sensitive and explosive.

SILICA—encountered as abrasive dusts, in metal finishing procedures, sand blasting, buffing, sanding, etc., and in lapidary work. Silicosis, a lung-scarring disease, results. Wear a mask for particulates. Some substitutes are silicon carbide, steel shot or glass beads.

SILVER COMPOUNDS—s. chloride and s. nitrate. Absorption of silver into the tissues is called argyria. This is indicated by a blue black discoloration in the skin and eyes. (This is not the same as when your skin will turn gray from silver jewelry – this is a coloration IN the skin that cannot be washed off.) These silver compounds harm the body when they are in vapor or dust form. When using mechanical devices for abrasion (sanding, buffing, etc.) of silver, wear eye protection because silver deposits in the eyes will cause night blindness. Other body parts affected are the lungs and kidneys.

SILVER SOLDER—frequently contains cadmium, brass (copper and zinc). All soldering should be done with good exhaust ventilation.

SOLVENTS—used for machinery clean-up and maintenance, dissolving plastics, and removing pitch. Solvents can enter the body by inhalation, skin absorption or ingestion. Ingestion is rare. Wash hands before going to eat. Wear gloves when working with solvents; do not smoke when using solvents (this also presents a fire hazard). Swallowing solvents is usually fatal and will cause blindness. All solvents should be used with good exhaust ventilation. The ventilation should be at the same level as the work rather than above the work. Gloves should be worn to prevent skin contact; solvents can dissolve the fatty layers of the skin and can cause systematic poisoning. See ACETONE, AMMONIA, BENZENE, KETONES, METHANOL, TOLUNE, TURPENTINE, XYLENE. Please note that this is a very broad definition for solvents. It would be wise to investigate more thoroughly the specific products in use in your own studio. When in doubt return solvents to a local distributor. If your supplier can't tell you who the distributor is, check with local machine shops, the national manufacturer or your state board of NIOSH.

STAINLESS STEEL—when welding stainless steel, harmful nickel compound fumes are produced. See section on NICKEL COMPOUNDS. Do all welding in a well ventilated area.

STYROFOAM—occasionally used for models for casting. Heating styrofoam for forming and for burnout releases toxic gases and requires efficient exhaust ventilation. All styrofoams are different. Contact your supplier for a Safety Data Sheet.

SULPHURIC ACID—used for cleaning metals. Very irritating to the respiratory tract, skin and clothes. SPAREX is a product used as a substitute for sulphuric acid. Both substances can be neutralized with bicarbonate of soda and water or soapy water. Many metalsmiths make the mistake of thinking that SPAREX is harmless. This is not true! Sparex is sodium bisulfate in granular form. This makes for safer, convenient storage than is possible with pure sulphuric acid. However, once Sparex is mixed with water, it is as comparatively dangerous as sulphuric acid, especially when it becomes concentrated due to water evaporation. When Sparex solution is heated, the fumes given off are equal to sulfuric acid fumes. Use ventilation.

SULFUR DIOXIDE—is found in fumes from tin compounds when they are melted. It is also a breakdown product of liver of sulfur. It is harmful to breathe sulfur dioxide gas. It is a highly soluble gas and dissolves in the watery passages of the breathing tubes. It does most of its damage in the upper respiratory tract which will then go into spasms and prevent the gas from getting further into the lungs. This gas is also encountered in environmental smog and is considered to be a major eye irritant. Use ventilation and/or appropriate respirator.

TALC—occasionally used as a separating agent with rubber molds and frequently used in plasters. Talc is mined from mineral deposits that frequently contain asbestos. So far, it has not been determined if the health problems caused by talc are from the talc, or the asbestos, or both. American talc tends to have less asbestos content than French. Like with asbestos, the lungs cannot remove talc. Most diseases related to talc take 20 to 30 years to show up. It is advised that a dust preventative respirator be worn because most damage caused by talc is to the respiratory tract.

TEFLON—dusts from Teflon are respiratory irritants and cause chronic bronchitis. Wear a mask for particulates.

TELLURIUM—fumes generated in copper, silver and gold refining and alloy making; also in welding. Extremely poisonous. Attacks the skin and the gastro-intestinal system. Early symptons are "garlic" breath and a metallic flavor in the mouth. Use good exhaust ventilation.

TIN COMPOUNDS—are harmful in dust form and in fumes. Tin is found in bronze alloys, pewter and solders. Organic tin compounds are skin-irritants. Stanosis is a "disease" caused by dusts of tin oxide that are in the lungs. These dusts are insoluble in lung tissue but are not irritating, do not cause symptoms and do not appear to cause disability. They WILL appear in X-rays of the lungs. However, if inorganic tin compounds are eaten, they can be fatal. Avoid breathing fumes and dust.

TITANTIUM—metallic titanium, as encountered by most metalsmiths, has not been traced to any occupational health problems.

TOLUENE/TOLUOL—is an alternative solvent for BENZENE. Its flash point is 40 degrees F. It can produce intoxication, hallucinations, lung and brain damage and fatal cardiac arrythmyias. Toluol can damage the red blood cells. It should be used with the appropriate ventilation.

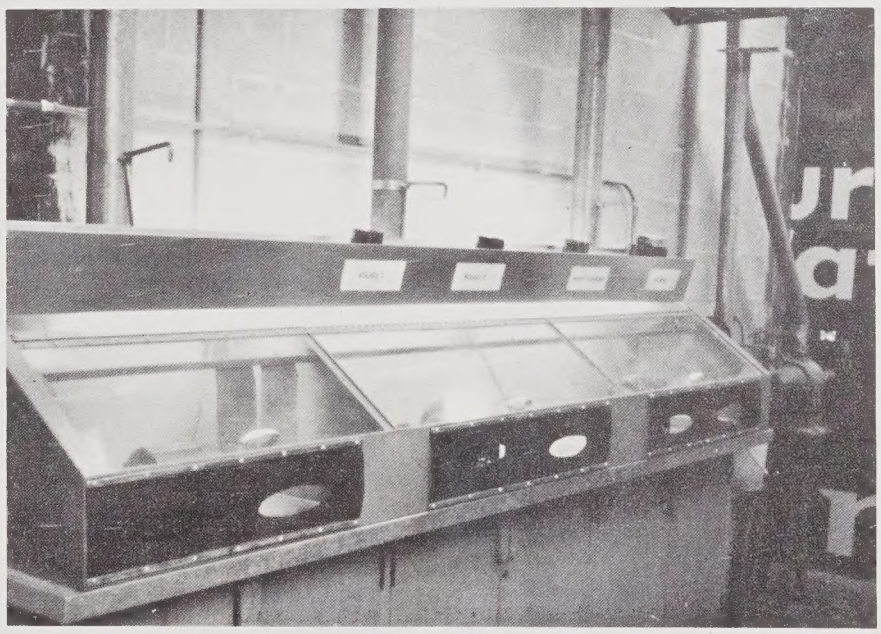
TURPENTINE—is not as flammable as other solvents. It is a skin irritant and harmful to the brain and lungs. Wear gloves and work in a ventilated area.

WAX—many of the waxes that are used for models for casting contain plastics to give them desirable working characteristics. When these waxes are melted for modeling or burnout, the plastics can give off harmful vapors which should be avoided.

XYLENE—alternative solvent for BENZENE. It is a skin irritant; dissolves the fatty tissues; can cause a decrease in the number of red and white blood cells. It is an eye and upper respiratory irritant. Wear gloves and use good ventilation.

ZINC COMPOUNDS—are found in solders and alloys of brass, bronze, German silver and gilding metals. Zinc acetates and zinc oxide are harmful in dusts and fumes. All soldering and welding should be well ventilated. The parts of the body affected are the central nervous system, lungs and skin (dermatitis). Symptoms of zinc oxide fume poisoning are nervousness and depression and metal fume fever. Metal fume fever indications are: flu symptoms, muscular aches and pains, chills, fever, nausea, burning throat, dry cough. This illness is usually very brief with complete recovery in 12 to 24 hours.

Many contemporary metalsmiths also use woods, leather and dyes, photography processes, and numerous machines. The sources listed in the bibliography will cover these and additional materials or processes that I have neglected to include.



Enclosed buffing machines with separate compartments for each compound. Each compartment has exhause ventilation and its own lights. With this type of system there is no need for respirators, goggles, face shields, etc. It is also possible to incorporate filters to trap precious metals.

HYGIENE: IN THE WORKSHOP AND PERSONAL HYGIENE

One of the best ways to decrease or eliminate a health hazard is to find a less toxic substitute. Some substances like asbestos, in particular, are so highly toxic that it is extremely difficult to work with it safely. This rule is true, in general, of all substances that can cause cancer since most current evidence indicates that there is no safe level of exposure to a carcinogen. It would be wise to follow this rule for all harmful substances.

When considering the layout for your shop, try to isolate the location for processes that produce or involve health hazards to one section (room) of the studio, and give this area special attention such as lighting, ventilation, sinks for quick clean-ups, etc.

Good "housekeeping" and personal cleanliness are necessary to control and prevent health hazards in the workshop. Spills should be cleaned up immediately. If the area or substance to be cleaned contains potential health hazards, one should wear gloves and a respirator. When cleaning up dusts, it is preferable to vacuum with an industrial-type vacuum, or wet mop, instead of sweeping.

You should not eat or smoke in the studio. Before eating or smoking, it is advisable to remove work gloves, bandanas, aprons, smocks, etc. Hands should be washed after using toxic substances. (Gentle hand soap is adequate. Harsh detergents can aggravate or cause dermatitis.)

If you live and work in the same place, a separate area should be set aside for your studio. One should be careful not to carry contaminants out of the studio into the living environment and into contact with other members of your household. Children, especially, are much more susceptible to harm caused by toxic substances. Work clothes should be left in the studio, washed frequently and separately from non-work clothes.

It is also important to store all potentially hazardous substances in their original container according to the manufacturer's instructions.

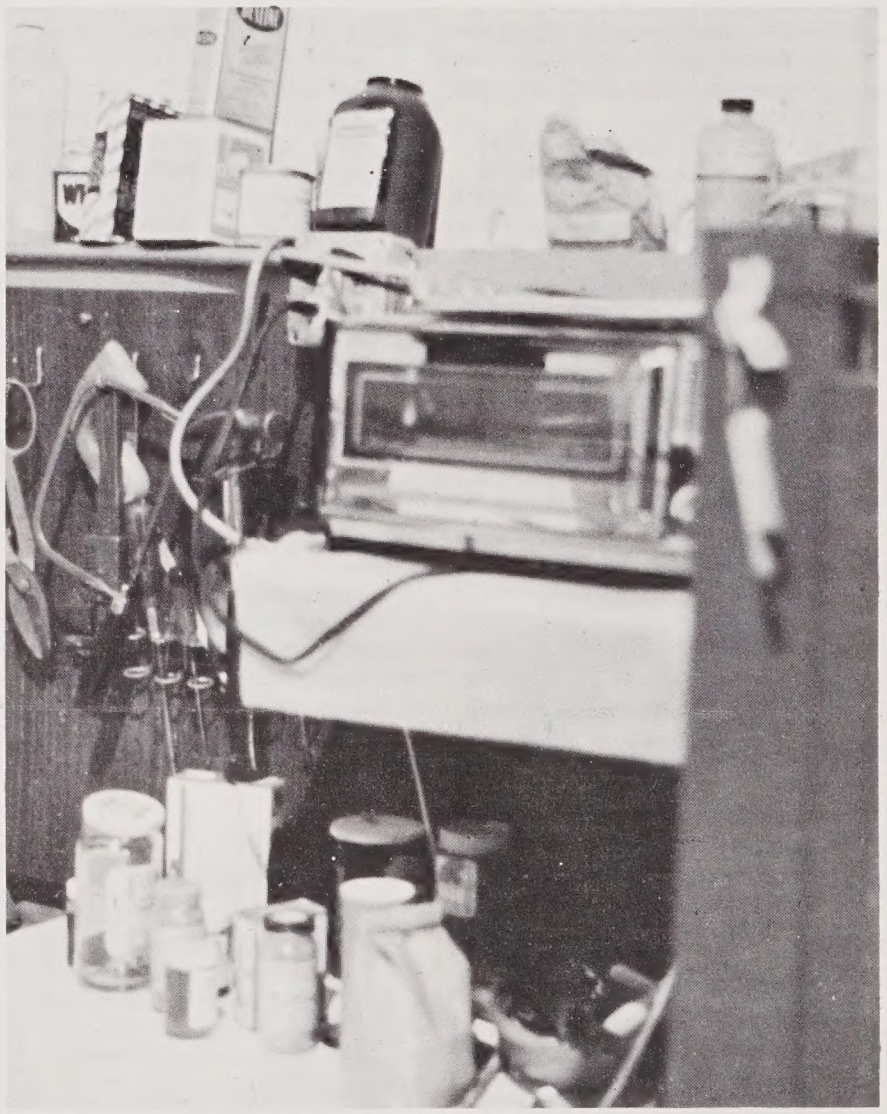


PHOTO A – Food items and a toaster oven sitting under potentially harmful chemicals and next to a work area. These should be isolated away from the work area.

PHOTO B–Drinking glasses are on the shelf. Drinking mugs are on the wall. On the shelf and counter are various potentially harmful acids and chemicals. Eating implements should be isolated away from the working environment.

SAFETY WITH EQUIPMENT MACHINERY

Welding, Soldering and Brazing: Fuel cylinders should be kept free from oily or greasy substances and should not be handled with oily or greasy gloves. Cylinder valves should be closed, and the fuel hoses bled when moving the cylinder and/or leaving the studio.

Cylinders should be marked boldly and legibly as to contents. Unlabeled cylinders should not be used. Empty cylinders should be marked as such at the time of depletion.

Cylinders should be stored in a well-ventilated area, away from heat in excess of 125 degrees F. Cylinders should be maintained in an upright position and should be stored in an assigned area away from any danger of being knocked over. Some type of chaining or bracket is advised for maintaining and securing the cylinder in an upright position.

A leaking cylinder (or valve) or one in need of repair should be marked boldly and legibly and removed to outside and the manufacturer notified. Never test for a gas leak with a flame. Use an approved leak detector solution. These may be obtained wherever you purchase your fuel or cylinder.

Only approved hoses and connections should be used. Hoses should be color-coded: RED=fuel gases and GREEN=oxygen or air. Hoses should be replaced when they leak or exhibit any other defects.

Regulators should only be repaired by authorized and trained personnel, preferably the supplier. Regulators should not be removed until the cylinder valve is closed and the hoses and regulator drained (bled).

All welding, cutting, soldering should be done in a designated area free of flammable conditions and substances. Your shop should be equipped with an appropriate number of portable fire extinguishers.

The physical hazards involved in welding and soldering are: burns and breathing of harmful fumes. In addition, welding produces excessive infrared and ultraviolet radiation. This radiation can cause burns like sunburn to the skin and heat cataracts if eye protection isn't worn. All soldering should be done in an area with good ventilation. Welding requires, in addition to ventilation, protective clothing, eye, and face protection.

METALWORKING MACHINERY

When working with machines, do not wear loose, sloppy fitting clothing. Keep hair tied down and pulled back. Eye and face protection is advisable.

Machines and machine operators should not be positioned in aisles or walkways.

Electrically-powered machinery should be hooked up to an adequate power supply source (proper recommended voltage), and the equipment should be grounded. Wiring should be up-to-date. The studio should be equipped with a "DEAD MAN'S SWITCH" – a button to kill all power to machinery in the case of an accident or emergency.

Grinders and buffers should have appropriate safety guards and local exhause ventilation.

Casting machines should have splash guards around them. Burnout and enamelling kilns should have exhaust ventilation. Looking into a hot kiln without protective glasses or goggles can result in harm from infra-red (heat) radiation. This can cause heat cataracts.

For more specific information regarding metal saws, grinders, rollers, mills, etc., the Department of Labor has print-outs on Safety Standards by the Occupational Safety Standards Commission.

ILLUMINATION

The best indication of whether or not the lighting in the workshop is adequate is whether or not the workers have visual comfort.

Illumination is measured in foot candles and any light meter (like for photography) will measure this.

Machinery and equipment should (according to ANSI standards) be provided with a minimum of 50 foot candles light intensity to fall upon the general area. Fine bench and machine work and fine grinding and polishing will need 500 to 1000 foot candles. This can be obtained by supplementing general lighting with specialized lighting. When natural light is insufficient, artificial light should be provided. Try to avoid lighting that creates glare or casts shadows over the work area.

PROTECTIVE DEVICES

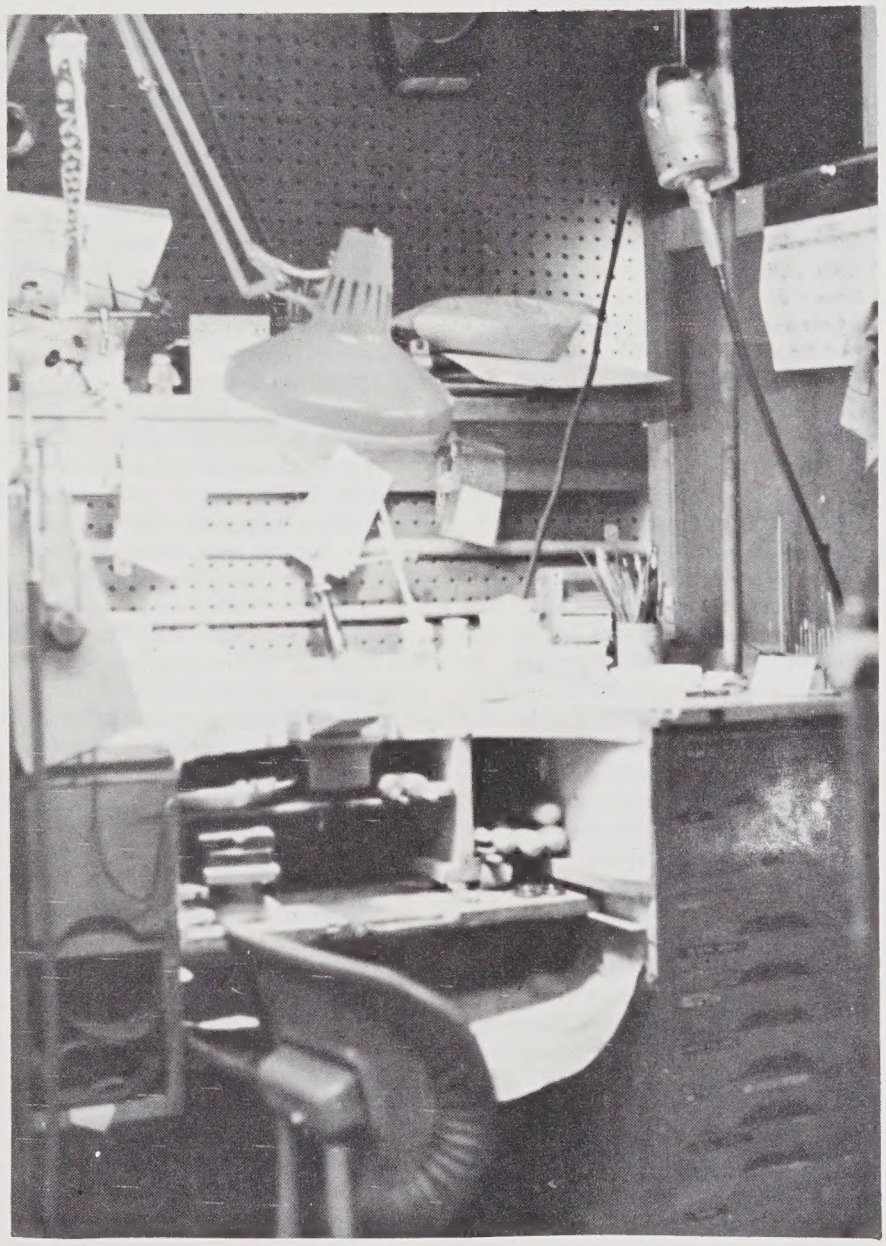
Respirators: According to the Occupational Safety and Health Act of 1970, respirators should only be used for "special emergency situations" where local exhaust ventilation is not possible, or as a temporary measure while local exhaust is being installed. Local exhaust ventilation is more efficient than a respirator, and respirators are uncomfortable to wear and difficult to breathe through.

There are two basic types of respirators: (1) air supplying—which provides a source of uncontaminated air for the person to breathe and (2) air purifying—which includes masks with appropriate filters.

The first type is fairly expensive and is recommended for situations where there is use of flouride fumes and welding of toxic heavy metals and presence of asbestos dust.

Masks and filters, in air purifying respirators, will have to have different cartridges for organic vapors (solvents); acid mists; dusts; and fumes.

Respirators should be labeled that they are approved by the Bureau of Mines or NIOSH (National Institute of Occupational Safety and Health). They should be considered effective only for the particular substances they were made for. It is very important that respirators fit properly and comfortably. Cartridges and filters should be changed regularly.



For further information concerning respirators, consult the American National Standards Institute booklet "Practices for Respiratory Protection", ANSI, Z88-2-1969, available from ANSI at 1430 Broadway, N.Y., NY 10018.

PHOTO C–Typical jewelers bench for soldering and finishing processes. There is no ventilation. The general lighting is very poor, but is supplemented with an excellent workbench lamp that has both a cool flourescent bulb and a 60-watt light bulb. The light fixture also has vent slots to prevent heat build-up, and it can be adjusted according to any convenient position.

VENTILATION—Please note that these are only general guidelines, not the specific information that would be needed to set up proper ventilation. Your state branch of NIOSH can refer you to a specialist in your area.

There are three basic methods of defending against airborne hazards such as dusts, fumes, vapors, particulates: (1) eliminate the hazard at its source; (2) ventilation; (3) protective devices (respirators, goggles). Solutions 2 and 3 seem to be the most frequently applicable solutions for the metalsmith.

One of the most important factors in designing a studio, and one of the most frequently neglected, is adequate ventilation. Basically, there are two types of ventilation: LOCAL EXHAUST ventilation removes the contaminants at their source before they can disperse in the air and enter people's breathing zones; GENERAL or DILUTION ventilation dilutes the harmful substances with fresh air to lower their concentration to a safer level. Obviously, the first method is preferred because it is more efficient in elimination of a hazard.

Some situations that call for local exhaust ventilation: SOLDERING, WELDING, BRAZING, ANNEALING, ACID BATHS, GRINDING, SANDING, POLISHING, KILN OPERATIONS, FORGE OPERATIONS (when indoors), MELTING PITCH, USING SOLVENTS, and WORKING WITH PLASTICS.

A Local Exhaust system consists of an exhaust hood to trap the contaminant, a duct system to carry the contaminant outside, an exhaust fan, and, ideally, air cleaning equipment to prevent contamination of the atmosphere.

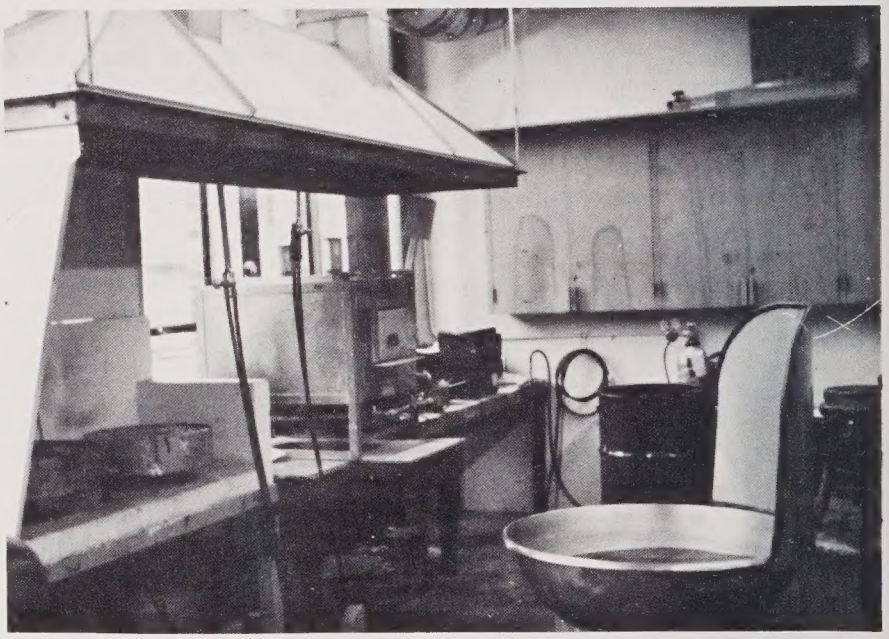
A General ventilation system replaces the air that is drawn out from Local Exhaust. The need for make-up air is frequently overlooked. If exhausted air is not replaced with fresh air, a negative pressure will develop in the room and the local exhaust system will not function properly.

There are many factors that affect the design and placement of an exhaust hood:

(1) The shape of the hood greatly affects its efficiency. It is most efficient to enclose the operation so that only contaminated air is drawn into the vent. On ventilation hoods located near a buffing wheel, baffle plates or lint screens are advisable so that the fans and ducts don't get clogged.
(2) Vent hoods should be located so that the natural velocity of the contaminant will be in the direction of the hood opening. This would pertain to exhaust ducts by buffing wheels and fume hoods above procedures that use heat (soldering, annealing, welding) because hot air rises. Solvent vapors are not heavier than air so exhaust for these fumes should be approximately at the same level that the vapors are produced.
(3) The hood should be placed as close to the contaminant as possible. Velocity of the exhaust decreases sharply as the distance from a vent hood increases.
(4) Hoods should be located so that contaminants are not drawn through people's breathing zones before being trapped in the hood.
(5) Make sure you have provided for an adequate source of make-up air to replace the air that is being drawn out, or negative pressure will result.
(6) The exhaust duct system should be made of materials that won't be affected by the contaminant, i.e., exhausts for organic solvents should be fireproof.
(7) To insure smooth air flow, ducts should be circular in cross section with as few bends in their length as possible. When bends are necessary, make them gradual.

The type and capacity of the fan will depend on the contaminant, the toxicity of the material, the amount in the air and the required air velocity to exhaust that contaminant. All of these variables can be measured.

Regarding these and other technical problems in safety and health hazards, your local state branch of OSHA will be able to help or refer you to another agency who can help.



Both the kiln and the annealing area have separate exhaust systems. Note the large stainless steel bowl and splash guard, this is filled with water *for quenching.*

PHOTO D—All Burnout Kilns should have exhaust ventilation. This type of duct system draws vapors directly from the kiln, it is preferred over the hood type exhaust ventilation.

PHOTO E—To the far left you will notice an alligator clip on the top of the container filled with stripping *solution. In the middle is the coffee pot and tea kettle. On the right is a pyrex pot full of sparex, which is not covered and is not in line with the draw of the exhaust hood.*

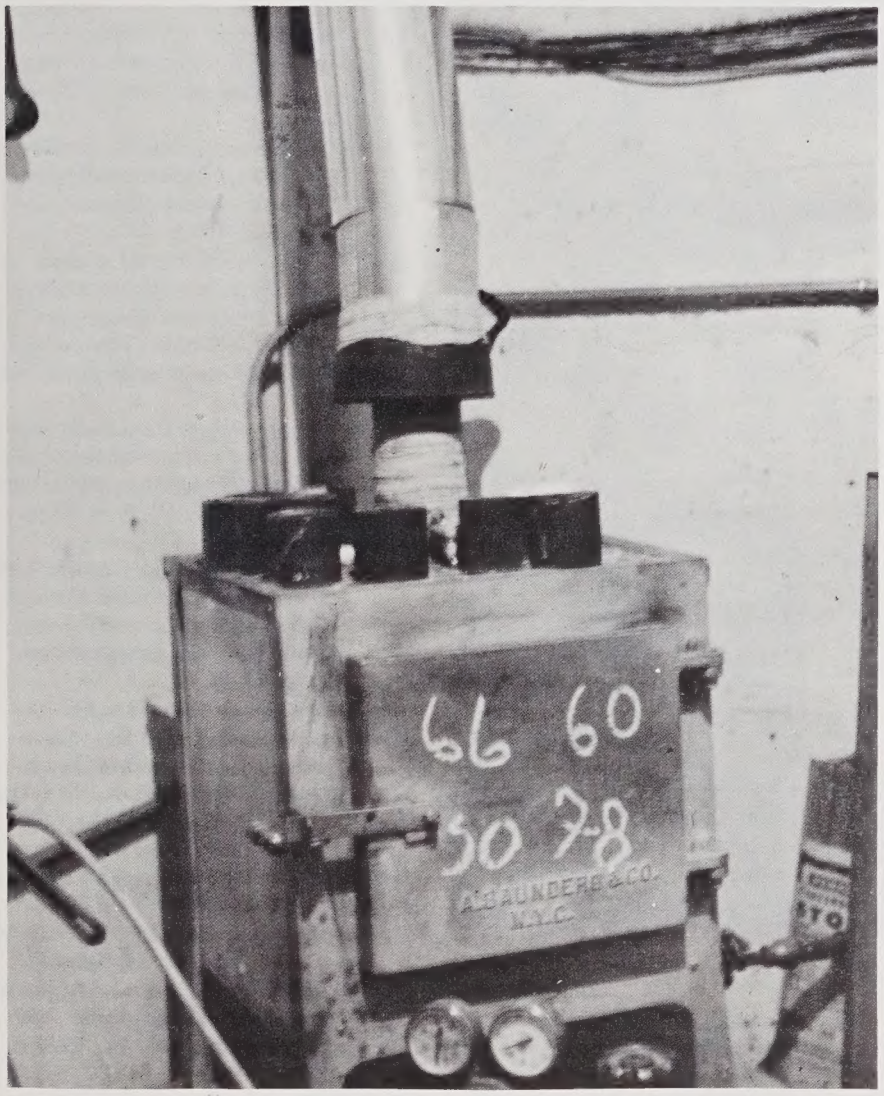
SKIN PROTECTION

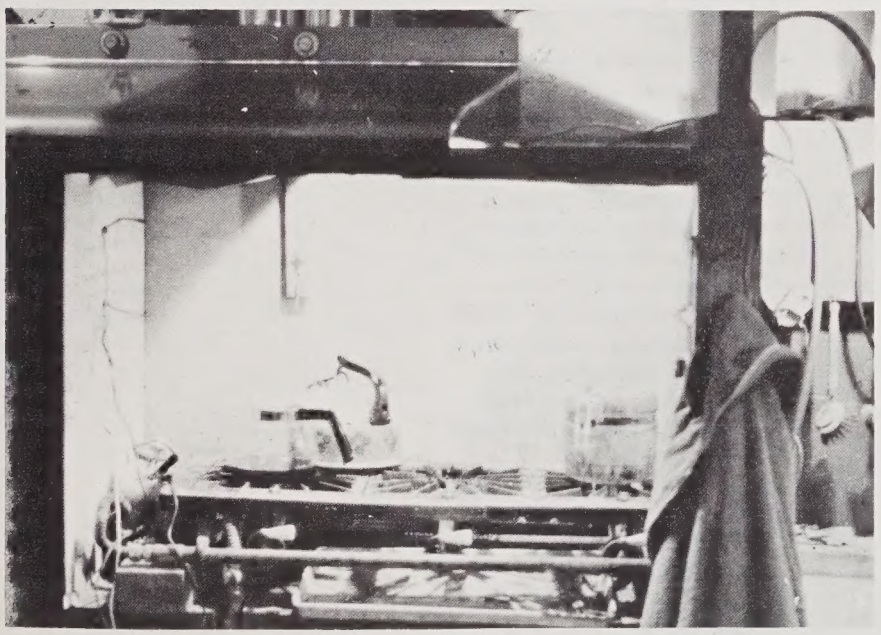
The best way to prevent skin irritation is to prevent skin contact with the irritating substance. The most common area of skin irritation for the metalsmith is the hands. When working with organic solvents, acids and other caustic substances, wearing rubber gloves is adequate protection. Surgical gloves will permit you to still feel the work.

Ketones will dissolve surgeons gloves and other poly vinyl gloves. Neoprene rubber gloves are good for acids and caustics.

Butyl rubber or natural rubber gloves can be used with ketones but not against aromatic hydrocarbons (toluol, xylol, polyester resins) or chlorinated hydrocarbons. Light cloth gloves may be used for other processes when desired. This is advised for the metalsmith who may spend long periods of time holding a vessel for raising and planishing sequences.

Leather gloves can be worn for protection during abrasive processes like grinding, sanding or buffing. Heavy leather gloves are good protection when dealing with heat from kilns, casting and hot pitch/pitch bowls.





PROTECTIVE CLOTHING

Basic common sense will usually guide the metalsmith in appropriate clothing for the studio. It is not wise to go barefoot or wear sloppy garments. Smocks are advisable for buffing and grinding operations. Leather aprons provide good protection when casting, buffing, grinding, and welding. Plastic aprons are good protection against acid splash.

EARS

Not all protective devices provide equal protection. The most protection is achieved from ear muffs. These are recommended for situations where there is a continuous noise level over 95 decibels (like using a drop forge hammer, or in a classroom with several students raising or forging at the same time, most lathes, milling machines). Ear plugs are not as effective. The best of these are the type that will mold to fit the individual's ear. Most reference books suggest that the plugs are more comfortable. It is advisable to try and eliminate most noise at its source.

FACE AND EYE PROTECTION

The face and eyes need to be protected from flying particles from machining and welding, radiation from welding and other heat producing processes, chemical splash, and acid or caustic mists.

Face masks and goggles are designed for each of the circumstances. Models are available that can be worn with or without glasses.

These devices should meet the specifications of NIOSH. For more information, refer to ANSI publication Z87.1, "Practice for Occupational and Educational Eye and Face Protection."

SOURCES OF APPROVED SAFETY EQUIPMENT (NIOSH or Bureau of Mines approved)

Respirators, goggles, aprons, gloves, ear muffs, etc.

Many of these companies have sales offices in other cities.

1. Glendale Optical Co., 130 Crossways Park Dr., Woodbury, NY 11797.
2. Guardian Safety Equipment Co., Box 455, Linden, NJ 07037.
3. Mine Safety Appliances Co., 201 N. Braddock Ave., Pittsburgh, PA 15208.
4. Pulmosan Safety Corp., 30-48 Linden Place, Flushing, NY 11354.
5. Safeline Products, P.O. Box 550, Putnam, CT 06260.
6. 3M Company, 3M Center, St. Paul, MN 55101.
6. Wilson Products Div., E.S.B., Inc., P.O. Box 622, Reading, PA 19603.

These companies will have local distributors in most areas.

NOTE: NIOSH=National Institute for Occupational Safety and Health

PHOTO F–A friend shows a quick alternative.

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NOTE: For specific product information (contents and/or hazards) you can write the manufacturer and ask for a MATERIAL SAFETY DATA SHEET.